

## **ALASKA FISHERIES SCIENCE CENTER**

### **EFFECTS OF FISHING GEAR ON SEA FLOOR HABITAT PROGRESS REPORT FOR FY 1999**

In 1996, the Alaska Fisheries Science Center (AFSC) initiated a number of sea floor habitat studies directed at investigating the impact of fishing on the sea floor and evaluation of technology to determine bottom habitat type (Heifetz, 1997). A progress report for each of the major projects is included below. Scientists primarily from the Auke Bay Laboratory (ABL) and the Resource Assessment and Conservation Engineering (RACE) Divisions of the AFSC have been conducting this work.

#### **A Description of Seafloor Habitat in a Trawled and Adjacent Protected Region of the Central Gulf of Alaska** Principal Investigator - Robert P. Stone (Alaska Fisheries Science Center - ABL)

During August 13-24, 1999 an occupied submersible was used to observe the seafloor at two areas near Kodiak Island that had been closed to bottom trawling since 1986. These areas were closed by the North Pacific Fisheries Management Council (NPFMC) to assist in rebuilding severely depressed crab stocks. Bottom trawl fisheries occur adjacent to the closed areas for walleye pollock, Pacific cod, flathead sole, butter sole, arrowtooth flounder, and several species of rockfish. The purpose of this study was to assess changes to the seafloor caused by chronic long-term trawling. Study objectives were to compare areas closed to trawling to areas open to trawling to determine if differences exist for infauna and epifauna species composition, abundance, and diversity, and substrate characteristics including grain-size composition, biogenic structures, and total organic carbon. This was the final cruise of a two-year study.

Two separate sites were studied in 1999 and were about 200 km apart along the eastern side of Kodiak Island. Observations were also made in June 1998 at two sites (one site was studied during both years). Moderate trawling had occurred at all three sites during the last five years. Forty four transects were completed and visual counts and observations were made over 136 km of the seafloor. Each transect was 3000 m long and bisected the boundary between open and protected areas. Substrate samples were collected with a Shipek bottom sampler along each transect.

The seafloor at the two 1998 study sites was a relatively flat and unstructured bottom comprised of mostly fine sand and silt interrupted only by dense beds of several species of sea whips. At both sites, sediments from trawled areas had higher concentrations of organic carbon (Figure 1) and coarser mean grain-size than sediments from protected areas. One possible explanation for the higher carbon level in the trawled areas is that it is redistributed from within the sediment layers to the surface by trawls. Sediment samples collected in 1999 are currently being analyzed for total organic carbon and grain-size properties. Infauna samples from both years should be analyzed by January 2000.

Evidence of bottom trawling (e.g., trawl door furrows, broken sea whips) were observed at about one-third of the transects at the Chiniak and Two-Headed Gully sites. The Trinity Island site was nearly devoid of sea whips, but trawl tracks were clearly visible over much of the seafloor in the area open to trawling. Fish and invertebrates currently being quantified from the video footage includes adult and juvenile flatfish, weathervane scallops, juvenile Tanner crabs, hermit crabs, shrimp, sea anemones, sea stars, and sea whips. Counts of megafauna have been completed on about 25% of the transects and all counts should be completed by October 2000.

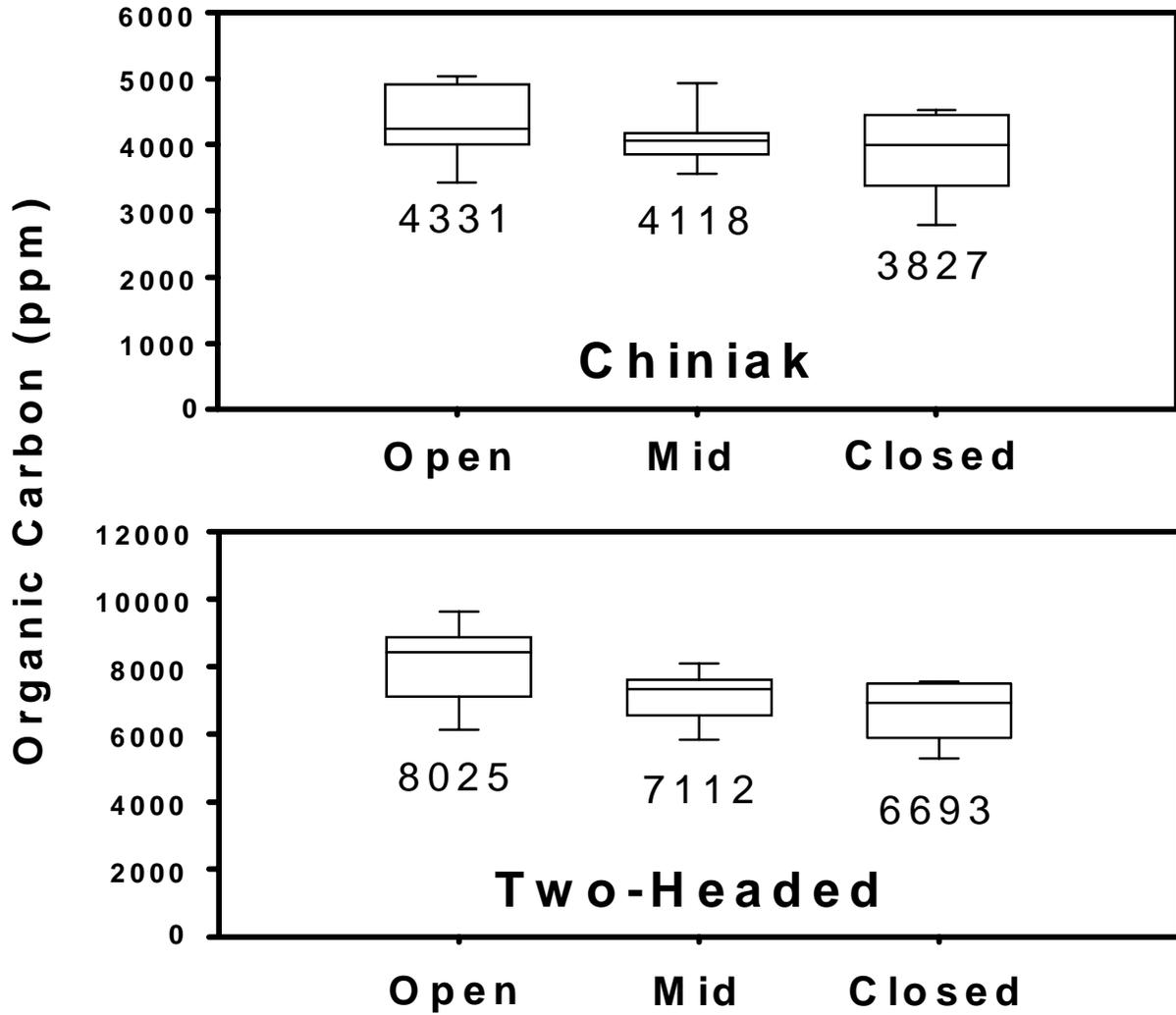


Figure 1. Boxplot diagrams of total organic carbon levels (ppm) in sediments from two areas sampled in June 1998 near Kodiak Island, Alaska. Samples (N = 10) were collected at three locations along a 3000 m transect bisected by the border between areas open to and closed to bottom trawling. Boxplots show the median, the upper and lower quartiles (top and bottom of box), and the 10<sup>th</sup> and 90<sup>th</sup> percentiles (error bars). "Mid" refers to the location along the transect that includes both the open and closed area.

**Trawl Impact Studies in the Eastern Bering Sea** Principal Investigator - Robert A. McConnaughey (Alaska Fisheries Science Center - RACE)

This project is examining possible adverse effects of bottom trawls on soft-bottom benthos in the eastern Bering Sea. Earlier studies revealed chronic effects on community diversity and on individual macrofauna populations (McConnaughey *et al.* 2000). However, interpretation of these findings and effective use for management purposes requires some understanding of the underlying processes. To address this need, a new multi-year study in the Crab and Halibut Protection Zone 1 (also known as management area 512) is being planned. Scheduled to begin in summer 2000, it will investigate acute effects and recovery from a single repetitive trawling event. Detailed physical information and historical trawl effort data have been assembled to identify suitable experimental sites (Marlow *et al.*, 1999; Smith and McConnaughey, 1999; unpublished data). Epifauna and infauna data collected in 1996 and 1997 are being analyzed to identify appropriate sample sizes for the research trawl (epifauna) and benthic grab (infauna) sampling efforts. Sidescan sonar, acoustic seabed classification and subsampling of benthic grabs will be used to characterize physical and chemical effects (in collaboration with scientists at the University of Alaska Fairbanks).

The before-after/control-impact (BACI) experimental design involves repeated sampling of specific sites to compare biotic and abiotic conditions before and after trawling. This requires accurate real-time positioning of sampling gear and the commercial trawl used to impact the experimental corridor. In May 1998, three ultra-short baseline (USBL) systems were tested in a fixed short baseline (SBL) tracking array maintained in Puget Sound by the U.S. Navy Naval Undersea Warfare Center Division Keyport. Using a chartered Bering Sea trawler operating under representative study conditions, this project demonstrated the feasibility of real-time trawl positioning. Comparison with Navy SBL fixes provided estimates of USBL positioning error for two systems, the Nautronix ATS II (3.7 m) and the ORE Trackpoint II Plus (5.9 m). When all other sources of error (e.g. errors due to GPS, the gyro and sound velocity estimates) are considered, along-track errors of 8.4 m and 10.6 m and cross-track errors of 11.6 m and 13.8 m, respectively, can be expected for a trawl fishing in 60-65 m of water. An over-the-side hydrophone pole suitable for chartered F/Vs was also developed and tested. Complete details are available in a Final Report, incorporating technical input from all contractors.

**Evaluation of Acoustic Technology for Seabed Classification** Principal Investigator - Robert A. McConnaughey (Alaska Fisheries Science Center - RACE)

Detailed knowledge of sea floor properties is required to design effective studies of fishing gear impacts. Because benthic organisms have strong affinities for particular substrates, experimental areas must be carefully selected so as to minimize confounding effects. Moreover, substrate properties may prove to be a useful stratification variable that will advance our research programs from exploratory case studies to more systematic study of benthic habitat sensitivity. Acoustic technology is particularly suited to synoptic substrate mapping since quantitative data are collected rapidly and in a cost-effective manner. A recently completed study demonstrated

that the *QTC View* seabed classification system (Quester Tangent Corporation, Sidney, B.C.; QTC) is capable of background data acquisition during routine survey operations (Collins and McConnaughey, 1998; von Szalay and McConnaughey, 2000). As part of large-scale studies to evaluate the utility of this system, an ISAH-S waveform recorder was installed aboard the research vessel *Miller Freeman* and adapted to the ship's EK-500 echosounder during gear trials in Puget Sound (24-30 March 1999). Subsequently, nearly 8 million digitized echo returns from the sea floor were collected along a 9,000 nm trackline in the eastern Bering Sea during a hydroacoustic fishery survey by the *Miller Freeman* (cruise MF 99-09, June-August 1999). Data were simultaneously collected at two frequencies (38 and 120 kHz). A quality assessment procedure indicates that data at both frequencies are of very high quality. Signal clipping was the most common deficiency and occurred in 10% of the high frequency data. A low signal to noise ratio was observed in less than 2% of the low frequency data. For each frequency, an optimum classification scheme will be identified using unsupervised classification methods and habitat maps will be generated. A specially configured *QTC View Series IV* will be deployed in summer 2000, as part of the acute trawl impacts study in the eastern Bering Sea. In addition to applications in gear impact studies, this technology may also be useful for characterization of groundfish habitat, given recent evidence that flatfish in the Bering Sea associate with particular sediment textures (McConnaughey and Smith 2000).

**Development of a Benthic Sled to Observe Seafloor Habitat** Principal Investigator - Ken Krieger (Alaska Fisheries Science Center - ABL)

Fishing impact studies by the ABL have depended on videos of the seafloor to quantify invertebrates and habitat. A manned submersible has been our primary method of collecting seafloor videos. A benthic sled was developed and tested in 1999 as a method of supplementing video collected via the submersible. The sled was constructed and tested in waters near Kodiak using video equipment that was developed for attachment to bottom-trawls. The sled was tested at speeds of 1-3 knots and it traveled smoothly on the seafloor and produced high quality video of the seafloor. A video system is currently being developed that will allow video to be collected at 2-4 knots and then replayed at slower speeds without a significant reduction in video resolution.

**Retrospective Analysis of Benthic Community Structure in Areas of High and Low Commercial Bottom Trawl Effort in the Gulf of Alaska and Aleutian Islands** Principal Investigators - Catherine Coon and Thomas C. Shirley (Juneau Center, School of Fisheries & Ocean Sciences, University of Alaska Fairbanks)

Species composition data from the 1990-1997 NMFS triennial bottom trawl surveys were analyzed to describe and compare attributes of community structure between areas of high and low bottom trawl concentrations for the Aleutian Islands and Gulf of Alaska. Locations of research trawl surveys were overlaid with bottom trawl effort data from the NMFS fishery observer database (NORPAC) for 1990-1998 (Coon *et al.*, 1999) and bathymetry of the area, using Geographical Information System (GIS) methodology. Areas of high trawl concentration (HTC, >364 days trawled/25 km<sup>2</sup>) that contained research trawl survey hauls were compared

with neighboring areas of low trawl concentration (LTC, 0 - 74 days/25 km<sup>2</sup> area) that also contained research trawl hauls, within 4 depth ranges (1-100, 101-200, 201-300, and 301-500 m). Not all areas of adjacent HTC and LTC also contained research trawl data; a total of 8 areas suitable for comparison were found. Only sessile or demersal and slow-moving, macrofaunal species (invertebrates and fish) that occurred in at least 10 trawls and were represented by at least 100 individuals were included in the analysis. Data on these species were standardized to represent individuals/10,000 m<sup>2</sup>. Population measures, including mean abundance, biomass, species richness and Shannon-Weiner diversity indices, were calculated for each site by depth and trawl concentration. A multivariate, non-multidimensional scaling metric was applied to dissimilarity matrices (Bray-Curtis) to help identify community relationships not amenable to univariate techniques.

The null hypotheses: 1) that decreased species richness; and, 2) lower average biomass occurred, in areas of HTC than LTC of similar depth, were tested for each of the eight sites to examine potential trawl effects. There were no consistent trends within or between sites that could uniquely identify trawl effects. Measuring trends in disturbance to quantify trawl effects were difficult at this spatial scale; apparently, commercial trawlers target HTC areas because they contain higher concentrations of fish, which persist at higher levels post-trawling than in LTC areas. However, useful information on species assemblages and associations could be documented in areas of fishing effort. Predominant species groupings of the five top fish/invertebrates species were quantified for each of the four depth categories. Common numerically predominant species included: Pacific ocean perch (*Sebastes alutus*), northern rockfish (*S. polyspinis*), arrowtooth flounder (*Atheresthes stomias*) and two species of sculpin for eight sites in the analysis. Species associations could be plotted with potential indicator species of bottom or sediment types to determine a more robust description of habitat. Using GIS layers to describe spatial patterns of demersal community structure may provide managers a tool to help document habitat areas of particular concern on small geographic scales.

### **Observations of One Year Old Trawl Tracks from a Research Submersible** Principal Investigator - Lincoln Freese (Alaska Fisheries Science Center - ABL)

An experiment (Freese *et al.*, 1999) conducted on hard bottom (pebble, cobble and boulder) substrate on the continental shelf break at depths of 206 - 274 m in the vicinity of Kruzof Is., Alaska showed that a single pass of a commercial trawl can reduce densities, and increase incidence of damage to several taxa of sessile invertebrates, including sponges and anthozoans. The experiment also showed that bottom trawling can disturb abiotic habitat features by dislodging boulders and causing grooves up to 8 cm deep in the substrate. Personnel from the ABL returned to these trawl tracks one year after trawling and made observations from the research submersible *Delta*. Trawl tracks were readily identifiable and there appeared to be minimal backfilling of grooves in the substrate caused by the prior year's trawling. Numerous large sponges that had been dislodged from boulders by the previous year's trawling activities were seen lying on the substrate within the trawl tracks. No evidence of regrowth was observed for sponges that had been damaged by the trawl but were still erect and attached to boulders. On the other hand most sponges, including those lying on the substrate and those damaged but still

erect, still appeared viable. These observations indicate that habitat modification and damage to some invertebrate species caused by trawling in the Gulf of Alaska may be long lasting.

### **Effects of Trawling on Hard Bottom Habitat in the Aleutian Region at Seguam Pass**

Principal Investigator - Harold Zenger (Alaska Fisheries Science Center - RACE)

The area around Seguam Pass has been fished for decades, and at one point the NPFMC cited it as possibly having experienced significant trawl damage, especially to gorgonian corals. In response, a study was initiated to visually verify the status of the demersal environment in Seguam Pass. A simple, robust observation platform was required, because the passes that cross the Aleutian Archipelago are notorious for swift currents and very irregular terrain, making the use of submersibles and ROV's impractical. Scientists adapted the design for a "Towed automatically compensating observation system" or TACOS, developed by engineers and scientists at the CSIRO laboratory in Hobart, Tasmania. The apparatus uses a color underwater video camera and AC lighting. Electricity and video signals are transmitted through an electrical tow cable as the camera frame tracks 1-2 meters above bottom. In flat towing attitude, distance above bottom is controlled by counterbalancing flotation with the weight of a drag chain. Live-feed video on the tow vessel's bridge allows the operator to control the amount of deployed cable, responding to changes in the terrain.

In August 1999, a 14-day cruise was conducted aboard the chartered fishing vessel *Vesteraalen* to gather underwater video images of the demersal habitat in the Seguam Pass area. The objectives of this study were: 1) examine whether the corals in heavily trawled areas are more damaged and less abundant than in nearby, less trawled areas; and, 2) attempt to verify the extent to which fish and invertebrates use coral for shelter. Twenty-five successful camera tows were completed. Images were recorded digitally on videotape. The videotapes are currently being reviewed and evaluated at AFSC in Seattle. In general, the study area is extremely varied, ranging from dense "gardens" of benthic invertebrates to large underwater sand dunes. On several occasions what appeared to be Atka mackerel spawning activity on large, offshore rockpiles and pinnacles, was recorded.

### **Habitat Areas of Particular Concern: Description and Distribution of Coral in the Gulf of Alaska and Bering Sea**

Principal Investigator - Jonathan Heifetz (Alaska Fisheries Science Center - ABL)

In June 1998, the North Pacific Fishery Management Council adopted amendments to fishery management plans that describe essential fish habitat (EFH) for managed species, as phase one in the EFH process. Included in phase one was the identification of Habitat Areas of Particular Concern (HAPC). The intent of HAPC is to identify those areas and habitat types that are known to be important to species and need additional levels of protection from adverse effects. Living substrates in shallow water (e.g., macroalgae, tube building polychaete worms, kelp, mussels, and erect bryozoans), living substrates in deep water (e.g., coral, anemones, and bryozoans), and freshwater areas used by anadromous fish were identified as HAPC. Phase two in this process is to identify additional HAPC and establish conservation measures to minimize, to the extent practicable, adverse impacts from fishing threats on HAPC.

Coral has been identified as a Habitat Area of Particular Concern (HAPC). To aid the NPFMC in identifying fishery management actions to minimize the adverse impacts on coral, information is being analyzed on the distribution and abundance of corals in Alaska and the species of fish managed by the NPFMC that are associated with coral. In addition a study has been initiated on the age and growth of gorgonian corals in collaboration with scientists at the Moss Landing Marine Laboratory in California. The taxonomic groups of coral found off Alaska are Alcyonacea (soft corals), Gorgonacea (sea fans and bamboo corals), Scleractinia (cup corals or stony corals), Stylasterinrina (hydrocorals), and Antipatharia (black corals). Given their size and longevity, gorgonian corals may also be most vulnerable to fishing impacts. The habitat created by gorgonians can be occupied by communities with high biodiversity and can be sources of shelter for fish (Risk *et al.*, 1988; Fossa *et al.*, 1999; Krieger and Wing, 1999)

Data being analyzed includes records of coral in the NMFS research survey database, the NMFS observer database (NORPAC), and the literature. The observer database includes records back to 1987 of coral that is incidently caught by fishing gear. Unfortunately, there is no taxonomic identification of coral in the database, and coral is combined with bryozoans as a common code in the database. Thus, the observer data base is being used mostly to supplement trawl survey data and to document the types of fishing gear that incidently catch coral.

In the survey data soft coral, primarily (*Eunepthya* formerly *Gersemia*, was the most frequently encountered coral in the Bering Sea. Over 96% of the coral encountered in the Bering was soft coral. In the Aleutian Islands soft coral was the least frequently encountered type. Only 21% of the coral encountered in the Aleutian Islands was soft coral. Gorgonian coral was the most frequently encountered coral in the Aleutian Islands. About 46% of the coral encountered in the Aleutian Islands was gorgonian coral, primarily *Primnoa* sp., *Paragorgia* sp., and *Fanellia* sp. Gorgonians and cup coral were the most frequently encountered coral types in the Gulf of Alaska. About 45 % of the coral encountered in the Gulf of Alaska was gorgonian coral, primarily *Callogorgia* sp. and *Primnoa* sp. About 31 % of the coral encountered in the Gulf of Alaska was cup coral, consisting mostly as “unidentified” cup coral (i.e., “Scleractinia unidentified”).

Some fish groups appeared to be associated with particular types of coral. Relative to the other coral types, rockfish, sablefish, Atka mackerel, and arrowtooth flounder were infrequently found with soft coral. On the other hand, gadids, Greenland turbot, greenlings, and other flatfish were found with soft coral in the highest relative proportion. Sharks and skates were found in hauls with hydrocoral and gorgonians in the highest relative proportion. Relative to the other coral types arrowtooth flounder were less frequently found on soft coral.

One alternative the NPFMC is considering is to close to fishing areas that have the highest abundance of coral. For gorgonian corals, this would include areas in the vicinity of Attu and Kiska Islands in the Aleutian Islands and areas off the end of the Kenai Peninsula and in Dixon entrance in the Gulf of Alaska.

## **Identification of a Possible Habitat Area of Particular Concern from a Research Submersible** Principal Investigator - Lincoln Freese (Alaska Fisheries Science Center - ABL)

A proposed alternative in the 1999 NPFMC Draft EA/RIR would amend Fishery Management Plans to include deep-water seamounts and shallower pinnacles as Habitat Areas of Particular Concern. These habitat features are often highly productive because of their physical oceanography, and host a rich variety of marine fauna (Probert *et al.*, 1997). Perusal of oceanographic charts for the Gulf of Alaska reveals that these features are relatively rare. In August 1999 personnel from the ABL conducted two dives on an isolated pinnacle from the research submersible *Delta*. The pinnacle is located on the continental shelf approximately 40 nautical miles south of Kodiak, Alaska (56° 17' N; 154° 01' W) and rises from a depth of about 40 meters to within 16 meters of the surface. The surrounding habitat is relatively featureless sand. The pinnacle hosted large aggregations of dusky rockfish (*Sebastes ciliatus*), kelp greenling (*Hexagrammos decagrammus*), and lingcod (*Ophiodon elongatus*), similar to aggregations noted on a pinnacle located in the vicinity of Cape Edgecumbe, Alaska (NPFMC, 1998). The pinnacle provides substrate for dense aggregations of macrophytic kelps beginning at the 20 meter isobath and continuing to the top of the pinnacle. These kelp beds may provide essential rearing habitat, as evidenced by the numerous juvenile fish (presumably *Sebastes* sp.) observed swimming among the kelp fronds. Although no evidence of fishing gear impacts were noted from the submersible, it is located on the Albatross Bank, an area that is extensively trawled (Coon *et al.*, 1999).

### **Literature Cited**

- Collins, W.T. and R.A. McConnaughey. 1998. Acoustic classification of the sea floor to address essential fish habitat and marine protected area requirements. Pages 369-377 in Proceedings of the 1998 Canadian Hydrographic Conference, Victoria, B.C.
- Coon, C., T. C. Shirley, and J. Heifetz. 1999. Spatial and temporal patterns of bottom trawling in the Gulf of Alaska and Aleutian Islands during 1990-1998. NOAA Tech. Rep. (Submitted August 1999).
- Fossa, J.H., D.M. Furevik, P. B. Mortensen, and M. Hovland. 1999. Effects of bottom trawling on Lophelia deep water coral reefs in Norway. Poster presented at ICES meeting on Ecosystem Effects of Fishing, March, 1999. Institute of Marine Research, Bergin, Norway.
- Freese, Lincoln, P. J. Auster, J. Heifetz and B. L. Wing. 1999. Effects of trawling on seafloor habitat and associated invertebrate taxa in the Gulf of Alaska. Mar. Ecol. Prog. Ser. 182:119-126.
- Heifetz, J. (ed.) 1997. Workshop on the potential effects of fishing gear on benthic habitat. NMFS AFSC Processed Report 97-04. 17 pp.

- Krieger K. J. and B. L. Wing. 1999. Megafauna associations with gorgonian corals (*Primnoa* sp.) in the Gulf of Alaska. *Marine biology*. (submitted)
- Marlow, M.S., A.J. Stevenson, H. Chezar and R.A. McConnaughey. 1999. Tidally-generated seafloor lineations in Bristol Bay, Alaska. *Geo-Marine Letters* (in press).
- McConnaughey, R.A., K. Mier and C.B. Dew. 2000. An examination of chronic trawling effects on soft-bottom benthos of the eastern Bering Sea. *ICES J. Mar. Sci.* (in press).
- McConnaughey, R.A. and K.R. Smith. 2000. Associations between flatfish abundance and surficial sediments in the eastern Bering Sea (in review).
- NPFMC. 1998. Environmental Assessment/Regulatory Impact Review for Amendment 59 to the GOA Groundfish FMP: Prohibiting anchoring and fishing on the Cape Edgecumbe Pinnacles. North Pacific Fishery Management Council. 605 West 4th Ave. Suite 306, Anchorage, AK 99501.
- Probert, P. K., D. G. McKnight, and S. L. Grove. 1997. Benthic invertebrate bycatch from a deep-water trawl fishery, Chatham Rise, New Zealand. *Aquat. Conserv. Mar. Freshwat. Ecosys.* 7:27-40.
- Risk, M. J., McAllister D. E., and Behnken, L. 1998. Conservation of cold-and warm-water seafans: Threatened ancient gorgonian groves. *Sea Wind* 10(4): 20-22.
- Smith, K.R. and R.A. McConnaughey. 1999. Surficial sediments of the eastern Bering Sea continental shelf: EBSSSED database documentation. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-104. 41 p.
- von Szalay, P.G. and R.A. McConnaughey. 2000. The effect of slope, vessel speed on the performance of a single beam acoustic seabed classification system. *Fish. Res.* (in review).